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SOIL CONTAMINATION AT ELEVEN WOOD PROTECTION FACILITIES IN THE ATLANTIC REGION IN 1989

Surveillance Report EPS-5-AR-91-1
Atlantic Region

Canada

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SOIL CONTAMINATION AT

ELEVEN WOOD PROTECTION FACILITIES

IN THE ATLANTIC REGION IN 1989

L. A. Rutherford, P. A. Hennigar,
W. H. Horne

Environmental Protection
Conservation and Protection
Environment Canada
Atlantic Region
1991

EPS-5-AR-91-1

PREFACE

This study was undertaken in order to determine whether wood protection activities were resulting in localized soil contamination at concentrations requiring action. While the study did document soil contamination which exceeds the Canadian Council of Ministers of Environment remediation criteria, it was not sufficiently comprehensive to determine the extent of contamination at each site. It must be recognized that this study represents a "snapshot in time" and that regional wood protection practices may have changed since the study was undertaken. As of December 31, 1990, the registration of pentachlorophenol as an anti-sapstain treatment, was terminated in Canada. Therefore, as existing stocks of PCP are depleted, soil residue concentrations of that chemical will decline due to natural degradation processes.

The results of the study will be used by governments and industry in the development and implementation of a code of good practice for the wood protection industry in eastern Canada. That industry must and will have a major role in addressing the identified environmental problems.

ABSTRACT

Surface soil samples were collected at eleven wood protection facilities in the Atlantic Region in 1989 in order to determine the concentration of contaminants at those sites. Results indicated that surface soils were heavily contaminated by chlorophenols and contaminated by boron, particularly within 10 m of treatment areas. Mean PCP concentrations were 322 ug/g within 1 m of dip tanks, 227 ug/g 1 to 10 m from dip tanks and 0.51 ug/g in treated lumber storage areas. Boron concentrations averaged 187 ug/g within 10 m of treatment areas and 44 ug/g in lumber storage areas where borax-based wood protection chemicals had been used. The widespread contamination observed at those facilities may be attributed to operational procedures which lacked sufficient environmental protection measures (e.g. lack of drip pads near treatment areas, inadequate amount of time in drip areas). The highest concentrations of chlorophenols and boron in the surface soils at those sites exceed current Canadian assessment and remediation criteria for contaminated sites. In addition, the high concentrations of chlorophenols could pose a serious threat to the aquatic environment and groundwater supplies near those operations.

RÉSUMÉ

En 1989, on a recueilli des échantillons de sol en surface dans onze installations de traitement du bois de la région de l'Atlantique afin de déterminer la concentration de contaminants. D'après les résultats des analyses, la couche de surface de ces sols était très contaminée par des chlorophénols et contaminée par du bore, surtout à moins de 10 m des zones où le bois est traité. La concentration moyenne de PCP était de 322 ug/g à moins de 1 m des cuves d'immersion, 227 ug/g entre 1 et 10 m des curves et de 0.51 ug/g dans les zones d'entreposage du bois traité. La concentration moyenne de bore était de 187 ug/g à l'intérieur de 10 m des zones où le bois est traité et de 44 ug/g dans les zones d'entreposage de bois où des produits chimiques à base de borax pour la protection du bois ont été utilisés. La contamination étendue du sol de ces installations peut être attribuée à l'utilisation de méthodes n'ayant pas suffisamment de contrôles pour la protection de l'environnement (p. ex., absence de plaques absorbantes pour recueillir le liquide d'égouttage dans la zone de traitement, séjour insuffisant en égouttage). Les concentrations les plus élevées de chlorophénols et de bore dans la couche de surface du sol de ces installations dépassent l'actuel critère canadien pour l'évaluation et la réhabilitation de sites contaminés. De plus, les concentrations élevées de chlorophénols pourraient être un sérieux danger pour le milieu aquatique et les eaux souterraines à proximité.

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1. Introduction

Freshly cut green lumber is susceptible to attack by sapstain and mould fungi which grow in the surface layers (sapwood) of wood under warm and humid conditions. Although not affecting the mechanical strength of the lumber, the natural pigmentation of sapstain fungi stains the wood blue or black, while mould fungi result in pink, red, green, blue, gray or black surface discolouration. This discolouration or sapstaining reduces the marketability of the lumber. Sapstaining may be especially severe during overseas transit due to the warm, moist conditions of a ship's hold (Smith 1978; Konasewich et al. 1983).

Fungal growth on unseasoned lumber is enhanced by factors such as the availability of food source, optimum moisture content, temperature and oxygen supply. The most frequently used method of control is the application of fungicides which, when applied to wood, render it unacceptable as a food source for fungi (Smith 1978). The treatment of freshly cut lumber with anti-sapstain chemicals is commonly referred to as 'wood protection'.

Chlorophenol formulations have been widely used as sapstain preventives in the lumber industry in Europe, the U.S.A. and Canada. Chlorophenols are moderately persistent in the environment, can bioaccumulate and are highly toxic to aquatic organisms. In addition, pentachlorophenol (PCP) is contaminated with chlorinated dioxins and furans, some of which are highly toxic (Jones 1984; Jor s 1981). Concerns regarding the toxicity of chlorophenols and their byproducts has led to the banning of anti-sapstain products which contain PCP in Sweden and Finland (Mychem 1989; Kitunen et al. 1987). In Canada, the Province of British Columbia passed provincial regulations in 1989, under the Waste Management Act, restricting the use of chlorophenols in wood protection operations (Province of British Columbia 1989). The registration of all sapstain control uses of pentachlorophenol in Canada was terminated effective December 31, 1990 (Agriculture Canada 1990).

The persistence of chlorophenols in soil can range from a few weeks to several years (Garrett and Shrimpton 1988). In aquatic environments, residues of PCP and tetrachlorophenol (TTCP) have persisted for decades in

anaerobic sediments (Jones 1984). Despite the potential for chlorophenol degradation in the terrestrial and aquatic environments, residues may persist in areas receiving high or continuing inputs of these chemicals (Garrett and Shrimpton 1988; Kitunen et al. 1987).

In natural aquatic environments, bioaccumulation of chlorophenols in biota can be moderate to high. Jones (1984) cited a study by M.E. Fox and S.R. Joshi in 1983 that showed bioaccumulation of PCP and TTCP can vary from moderate in leeches (10^2) to high (approximately 10^4) in freshwater fish. Bioconcentration factors for PCP ranging from 13 to 1000 have been reported in freshwater and marine vertebrates (Gilman et al. 1988).

Chlorophenols are of toxicological significance to organisms in the environment, particularly the aquatic environment. Chlorophenols at ug/L concentrations may affect the survival, growth, metabolism and reproduction of aquatic organisms (Jones 1981; Garrett and Shrimpton 1988).

Studies undertaken in Europe have indicated that the normal operation of dip-treatment wood protection facilities which use PCP has lead to serious local contamination of soil and groundwater by chlorophenols (Kitunen et al. 1987; Valo et al. 1985; Valo et al. 1984), polychlorinated phenoxyphenols (Kitunen et al. 1987; Kitunen et al. 1985; Humppi 1984) and polychlorinated dibenzodioxins (Kitunen et al. 1987; Kitunen et al. 1985). In British Columbia, significant levels of chlorophenols have been detected in sediments, water and biota adjacent to several wood protection facilities (Can Test Ltd. and E.V.S. Consultants Ltd. 1979). Krahn and Shrimpton (1988) found, at five wood protection facilities in B.C., that dip treated lumber leachate had concentrations of 158,000 ug/L and maximum runoff concentrations of 6,600 ug/L total chlorophenols.

In 1989, 11 sawmills were known to be using anti-sapstain chemicals in Atlantic Canada. Six of those mills were located in New Brunswick and five in Nova Scotia. No sawmills in P.E.I. or Newfoundland were known to be conducting wood protection activities.

Approximately 1 million litres of PCP solution (2600 kg PCP) and 170,000 litres of 'Ecobrite®', a borax-based product, were used at those 11 mills (Agriculture Canada 1989). Six mills dipped spruce or fir for export markets and five mills dipped white pine or hardwoods for the domestic market.

The most common treatment method used in the region employed dip tanks loaded by fork lifts. In that method, bundles of lumber are immersed in water-based formulations either by a front-end loader equipped with a forklift attachment or a hydraulically-operated frame. A less frequent treatment method used was a sorting chain dip tank system which employs sprocket driven chains that carry individual pieces of lumber from the sawing and trimming portion of the mill through a dip tank to the end of the line where the lumber is bundled. The sawmill using that treatment method ceased wood protection activities in 1990. In almost all instances, regardless of the treatment method, basic design features for environmental protection (e.g. drip pads under dip tanks, covered dripping/drying areas) were not incorporated in the operations.

While the extent of environmental contamination at wood protection operations in other jurisdictions is well known, environmental sampling at wood protection facilities had not previously been conducted in the Atlantic Region. The purpose of this study was to determine the magnitude of soil contamination at Atlantic Region facilities, particularly in reference to operational practices used at the sawmills.

2.0 Methods and Materials

2.1 Site Selection

For the purposes of this study, only wood protection operations known to be active during 1989 were investigated. The 11 active sawmills sampled were identified by contacting representatives of provincial and federal environment departments, Agriculture Canada and the Maritime Lumber Bureau.

2.2 Sample Selection

Soil samples were collected to a depth of 5 cm using acetone and hexane rinsed stainless steel spoons. The samples were deposited into 500 mL clear glass jars that had been detergent washed and rinsed with distilled water, acetone and hexane. The sample bottles were tightly sealed with aluminum foil lined lids, stored in the dark and frozen for transportation to the laboratory. Samples remained at -20°C until analyzed.

Sample locations at each sawmill were determined by site conditions (terrain, soil type) and site operational procedures. An effort was made to secure samples at various distances from the dip tank, in treated lumber storage areas and adjacent to stored shavings from treated wood.
A total of 76 soil samples were taken at 11 wood protection facilities in New Brunswick and Nova Scotia between August 21, 1989 and September 7, 1989.

2.3 Chemical Analyses

2.3.1 Organic Analyses

Approximately 20 g of wet soil were weighed and thoroughly mixed with 5 mL 0.25 N HCl. The acidified sample was transferred to a 250 mL round bottom flask and extracted with 50 mL 50% benzene/acetone on a wrist action shaker for 20 minutes. The solvent was filtered and saved. The soil was re-extracted with an additional 50 mL 50% benzene/acetone. The combined filtered extracts were transferred to a separatory funnel containing 500 ml acidified water (pH=1). The separatory funnel was shaken vigorously for two minutes and the aqueous and organic phases allowed to separate. The benzene layer was collected and the aqueous phase re-extracted with two more 50 mL volumes of benzene. The combined extracts were dried over anhydrous sodium sulphate and evaporated just to dryness. The residue was taken up with 1 ml diethyl ether and any phenolic compounds present were

derivatized with diazomethane to the methyl esters. Following esterification, the diethyl ether was concentrated to near dryness, exchanged with hexane and the volume adjusted to 1 mL.

The concentrated extract was passed through on an acidic alumina column (1.0 cm x 5.0 cm, activated at 135°C for 12 hours). The column was eluted sequentially with 20 mL hexane (fraction 1), 30 mL 20% benzene/hexane (fraction 2) and 20 mL 20% diethyl ether/hexane (fraction 3). Fraction 1 was discarded. Fraction 2 which contained the methyl esters of di-, tri-, tetra-, and pentachlorophenol and fraction 3 which contained tetrachlorocatecol and tetrachloroguaiacol (previously derivatized to the methyl ester of tetrachlorocatecol) were saved. The two fractions were concentrated individually to a small volume in hexane suitable for instrumental analysis.

Esters of the chlorinated phenols and tetrachlorocatecol were analyzed on a capillary column - gas chromatograph coupled with an electron capture detector. Identification and quantitation of target compounds were conducted using external standard techniques.

Individual chlorinated phenolics were spiked into soil samples (0.1 - 0.2 ug/g) and processed through the full procedure. Replicate analyses yielded average recoveries of 73 ± 20% (SD) for trichlorophenols, 89 ± 20% (SD) for tetrachlorophenols and 101 ± 25% (SD) for the pentachlorophenol.

Moisture content was determined for each sample and results of analysis expressed on a dry weight basis. The average moisture content of soil samples analyzed for chlorophenols was 20.2% ± 11.0% (SD).

2.3.2. Inorganic Analyses

All soil samples were dried at 100-105°C and ground to a fine powder (between 25 to 500 um pore size) using a mortar and pestle.

A number of pretests were conducted to ensure proper dissolution of the sample. The preferred procedure was to add 4 mL of concentrated sulfuric acid (H_2SO_4) to the 1.0000 g sample in a 150 mL beaker. The sample was heated to a minimum of 250°C until the fumes of sulfuric acid were observed. Heating was continued for an additional 15 minutes. The sample was cooled and transferred to 50 mL volumetric flasks, mixed well and allowed to settle over night.

All samples were analysed for boron using a Thermo Jarrell Ash ICAP model 61E plasma emission spectrophotometer.

A number of techniques were utilized for quality control/quality assurance. Precision was checked by analysing one sample (A5) with each of 5 sets of samples. The result was; mean 378 ug/g, SD ± 74. The calibration of the ICAP was checked using a 1.0 ppm boron standard while analysing samples. The 1.0 ppm standard was analysed 13 times with the following results; mean 1.065 ppm, SD ± 0.071. The average recoveries of four samples spiked with 1 mL of 1000 ppm B was 72.5%.

3.0 Results

Appendices A - K present maps showing sampling locations at each sawmill surveyed and analytical results for all samples collected.

Table 1 indicates that soils were heavily contaminated by chlorophenols at wood protection facilities using chlorophenate-based anti-sapstain chemicals. PCP accounted for 80.7% (range 72.9%-92.8%) of all chlorophenols found at the five sample locations. As expected, the highest contaminant concentrations were measured in close proximity to the dip tanks. The Newman-Keuls multiple range test (Zar 1974) indicated that there was no significant difference between PCP concentrations in soils 0-1 m from the dip tank compared to 1-10 m from the dip tank ($q = 1.15$, $\alpha = 0.1$). However, there were significant differences between PCP concentrations 0-1 m from the dip tank and sample locations greater than 10 m from the dip tank ($q = 3.14$, $\alpha = 0.1$) and treated lumber storage areas ($q = 3.81$, $\alpha = 0.1$).

TABLE 1 - Contamination of soil by chlorophenols at six wood protection facilities using chlorophenate-based anti-sapstain chemicals in 1989 (ug/g dry weight)

	PCP	2,3,5,6-TTCP	2,3,4,5-TTCP	TTCC	2,4,6-TCP	2,4,5-TCP	2,3,4-TCP	2,3,5-TCP	2,3,6-TCP	2,5-DCP
Sample Location 0-1 m from dip tank										
mean	322.21	86.88	0.44	3.38	0.02	0.46	0.12	0.01	<0.005	<0.1
SD	428.16	266.49	0.40	6.07	0.02	1.41	0.14	0.10	0.001	0.0
median	87.0	1.9	0.48	0.99	0.009	0.028	0.062	<0.005	<0.005	<0.1
range	5.2-1300.0	0.11-890.0	0.032-1.20	0.00096-17.00	<0.005-0.06	<0.005-4.70	<0.005-0.43	<0.005-0.37	0.0027-0.0085	-
n	11	11	11	11	10	11	10	11	9	11
Sample Location 1-10 m from dip tank										
mean	227.22	45.50	0.73	4.50	0.03	2.14	0.29	<0.005	0.009	<0.1
SD	299.02	104.67	1.40	15.28	0.05	6.90	0.53	0.0	0.009	0.0
median	123.50	0.67	0.147	0.036	0.012	0.012	0.005	<0.005	<0.005	<0.1
range	0.029-900.0	0.016-190.0	0.011-4.5	0.0032-53.0	<0.005-0.15	<0.005-24.0	0.005-1.60	-	<0.005-0.031	-
n	12	12	12	12	12	12	10	12	12	12
Sample Location >10 m from dip tank										
mean	6.97	0.28	0.04	0.09	<0.005	<0.005	0.01	<0.005	<0.005	<0.1
SD	16.67	0.62	0.08	0.21	0.0	0.0	0.02	0.0	0.0	0.0
median	0.145	0.004	0.005	0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1
range	0.0025-41.0	<0.002-1.40	<0.002-0.19	<0.0002-0.52	-	-	<0.005-0.52	-	-	-
n	6	5	6	6	5	5	6	5	5	6
Sample Location treated lumber storage area										
mean	0.51	0.05	0.01	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0
SD	0.97	0.08	0.01	0.02	0.0	0.0	0.0	0.0	0.0	0.0
median	0.12	0.014	0.004	0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1
range	0.013-3.10	<0.002-0.23	<0.002-0.03	0.00023-0.05	-	-	-	-	-	-
n	11	7	10	10	9	10	10	8	10	10
Sample Location shavings pile										
mean	0.71	0.02	0.03	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1
SD	0.54	0.03	0.01	0.01	0.0	0.0	0.0	0.0	0.0	0.0
median	0.68	0.013	0.03	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.1
range	0.093-1.40	0.0026-0.069	0.015-0.042	0.0005-0.016	-	-	-	-	-	-
n	4	4	4	4	4	4	4	4	4	4

PCP = pentachloropnenol, TTCP = tetrachlorophenol, TCP = trichlorophenol, TTCC = tetrachlorcatechol, DCP = dichlorophenol.
* two samples were excluded from this analysis: one under a bundle of lumber that had just been treated and was visibly dripping; one in a puddle directly under a bundle of lumber.

Buffers, such as sodium tetraborate and borax, are components of chlorophenate solutions used in the region. These substances keep the formulations alkaline, thereby facilitating the conversion from chlorophenate (in the water soluble solution) to chlorophenol (on the acidic surface of the lumber). Table 2 indicates that soils were variably contaminated by boron at wood protection facilities using chlorophenate-based anti-sapstain chemicals, with the highest concentrations of boron close to the dip tanks. Average boron concentrations within 10 m of dip tanks were 2.6 to 4.5 times higher than average natural background concentrations. The average natural background concentration in soil is 30 ug/g, ranging from 14 ug/g in igneous derived soils to 40 ug/g in sedimentary derived soils (Bingham 1973).

Soils were also contaminated by boron at wood protection facilities using borax-based anti-sapstain chemicals (Table 3). Boron concentrations in soils within 10 m of dip tanks were 5.9 to 6.2 times higher than average natural background concentrations, 5.2 times higher than background concentrations 10 m from dip tanks and 1.5 times higher in treated lumber storage areas. The highest concentrations of boron occurred in close proximity to the dip tanks, although multiple range testing indicated that there were no significant differences between boron concentrations in soils 0-1 m from the dip tank compared to the treated lumber storage area ($q = 2.07$, $\alpha = 0.1$). Boron concentrations in soils ranged from 30.7% to 494% higher at sawmills using borax-based anti-sapstain chemicals compared to chlorophenate-based formulations.

The highest concentrations of PCP measured in surface soils during the survey are presented in Table 4. Since PCP is not known to occur naturally, its environmental background concentration in soils should be zero, although anthropogenic sources have resulted in trace concentrations even in remote areas, generally at concentrations in the order of parts per billion (Shield 1985). The number of years that chlorophenate-based anti-sapstain chemicals had been used at a sawmill did not appear to effect the magnitude of surface soil contamination.

TABLE 2 - Contamination of soil by boron at six wood protection facilities using chlorophenate-based anti-sapstain chemicals in 1989 (ug/g dry weight)

	0-1 m from dip tank	1-10 m from dip tank	>10 m from dip tank	treated lumber storage area	shavings pile
mean	136.5	78.9	26.3	21.7	22.0
SD	164.9	113.7	10.5	3.6	5.0
median	58.0	29.5	26.0	20.0	20.5
range	21.0-522.0	19.0-417.0	12.0-44.0	18.0-29.0	18.0-29.0
n	11	12	6	11	4

TABLE 3 - Contamination of soil by boron at five wood protection facilities using borax-based anti-sapstain chemicals in 1989 (ug/g dry weight)

	0-1 m from dip tank	1-10 m from dip tank	>10 m from dip tank	treated lumber storage area
mean	178.4	187.0	156.3	44.0
SD	141.0	303.4	95.8	29.6
median	80.0	33.0	151.5	29.5
range	62.0-378.0	21.0-847.0	49.0-273.0	22.0-100.0
n	7	7	4	12

Surface soils at sites that had used chlorophenates for 1-2 years were as highly contaminated as ones that had used these chemicals for 35-40 years. However, given the tendency of cholorphenols to migrate in soil, (Valo et al. 1984; Valo et al. 1985; Kitunen et al. 1985) leaching of chlorophenols into lower soil horizons would be expected to be more pronounced at the sites that had operated for many years. Two sawmills that had been using chlorophenates for a relatively short period of time, had high concentrations of PCP in soils at most sample locations.

Table 5 shows the highest concentrations of boron in surface soils encountered during the survey. These concentrations range from 2.6 to 28.2 times higher than background levels. At one sawmill, high concentrations of boron in surface soils were measured over most of the site.

4.0 DISCUSSION

Chlorophenol and boron concentrations in surface soils at wood protection facilities in the region exhibited a high degree of variability. This was likely due to variable site conditions (e.g. soil types, site runoff patterns) and operational procedures (e.g. dripping time allowances, traffic pathways) at the sawmills. A similar degree of variability in data on chlorophenol concentrations in surface soils at Finnish wood protection facilities has been presented by Kitunen et al. (1987) and Valo et al. (1984).

Table 6 presents chlorophenol concentrations in surface soils at wood protection facilities in Finland. Soils at these facilities were considered heavily contaminated by the authors. Some soil samples collected at Atlantic Region wood protection facilities had significantly higher concentrations of PCP, 2,3,4,5-TTCP and 2,4,5-TCP. Generally, soils at Atlantic Region facilities exhibited a magnitude of contamination comparable to Finnish sites.

TABLE 4 - Highest concentrations* of PCP at wood protection facilities surveyed in 1989

Sample Location	Sample No.	Sawmill	Years chlorophenates used at sawmill	PCP (ug/g) dry weight
0-1 m from dip tank	K6	Sawmill K	2	1300.0
	D4	Sawmill D	35	930.0
	G1	Sawmill G	1	480.0
	K2	Sawmill K	2	340.0
1-10 m from dip tank	H5	Sawmill H	40	900.0
	K3	Sawmill K	2	710.0
	D1	Sawmill D	35	370.0
	D2	Sawmill D	35	250.0
	G5	Sawmill G	1	240.0
>10 m from dip tank	K5	Sawmill K	2	41.0
treated lumber storage area	K7	Sawmill K	2	1000.0
	G7	Sawmill G	1	180.0
shavings pile	K9	Sawmill K	2	1.4

* concentrations above mean values.

TABLE 5 - Highest concentrations* of boron at wood protection facilities surveyed in 1989

Sample Location	Sample No.	Sawmill	Years 'Ecobrite ® used at sawmill	Boron ug/g dry weight
0-1 m from dip tank	A5	Sawmill A	1	378.0
	E1	Sawmill E	1	355.0
	E2	Sawmill E	1	229.0
1-10 m from dip tank	E3	Sawmill E	1	847.0
	A6	Sawmill A	1	263.0
>10 m from dip tank	M4	Sawmill M	1	273.0
	M5	Sawmill M	1	186.0
treated lumber storage area	A4	Sawmill A	1	100.0
	A1	Sawmill A	1	95.0
	A3	Sawmill A	1	79.0

* concentrations above mean values

TABLE 6 - Chlorophenol concentrations in soils* at wood protection facilities in Finland (ug/g)

Reference	Sample Location	PCP	2,3,4,5-TTCP	2,4,6 - TCP	2,4,5 - TCP	2,3,4-TCP
**						
Kitunen et al. (1987)	5-30 m from dip tank	110.0	-	5.5	2.3	2.2
	" " "	0.7	-	0.3	0.1	<0.1
	" " "	81.0	-	8.0	4.6	1.0
	" " "	730.0	-	53.0	5.3	7.8
***						
Valo et al. (1984)	5 m from dip tank	0.8	0.004	0.3	0.03	0.004
	20 m from dip tank	45.6	0.3	1.8	1.0	0.8
	75 m from dip tank	0.2	-	0.05	-	-
	125 m from dip tank	0.1	-	0.05	-	-
	210 m from dip tank	0.01	-	0.02	-	-

* surface soil samples, 0 - 5 cm depth.
** data expressed in dry weight values
*** data expressed in fresh weight values, 6 to 12% moisture content.

PCP = pentachlorophenol TTCP = tetrachlorophenol TCP = trichlorophenol

Soil clean up criteria developed by the Government of the Netherlands, and adapted for use by the Province of Quebec, established 5.0 ug/g dry weight chlorophenols as severely contaminated soils requiring immediate clean up. Concentrations of 0.5 ug/g - 5.0 ug/g dry weight are moderately contaminated and require further investigation regarding contaminant mobility, the potential for adversely affecting public health, and future land use of the contaminated site (Environment Canada 1990). Based on these criteria, all wood protection facilities in the region using PCP had severely contaminated soils, usually in close proximity to the dip tank. Four of six sawmills using PCP had moderately contaminated soils in other locations on site.

Soil cleanup criteria for boron have been developed by the Government of France; 100 ug/g dry weight boron is the treatment threshold, the concentration above which treatment of the soil is required, and 200 ug/g dry weight boron is the emergency threshold, the concentration above which immediate action must be taken (Environment Canada 1990). Three of the five sawmills in the region using Ecobrite^{R} had soils in close proximity to the dip tank that exceeded the emergency threshold. Two of the six sawmills using PCP had boron contaminated soils that exceeded the emergency threshold and another two mills had boron contaminated soils that exceeded the treatment threshold.

The Canadian Council of Ministers of Environment (CCME) has developed interim environmental quality criteria for contaminated sites intended to protect, maintain or improve current and future use(s) of soil. CCME interim assessment criteria for chlorophenols and boron (hot water soluble) in soil are 0.05 ug/g dry weight and 1.0 ug/g dry weight respectively. When contaminant concentrations exceed those levels, investigative action should be considered to assess the extent of contamination, the nature of any hazards at a site, and to determine the scale and urgency of further action, if required. Based on those criteria, all wood protection facilities in the region using PCP and Ecobrite^{R} require investigative action. CCME interim remediation criteria for chlorophenols in soils at commercial/industrial sites are 5.0 ug/g dry weight. Using that criterion as a remediation objective, all wood protection facilities using PCP in the region would require

remediation to reduce levels of PCP contamination to 5.0 ug/g. Interim remediation criteria have not been set for boron at commercial/industrial sites (CCME 1991).

The chlorophenol contaminated surface soils at wood protection facilities in the region could adversely affect aquatic life in nearby freshwater ecosystems. Chlorophenols at ug/L concentrations may affect the survival, growth, metabolism and reproduction of aquatic organisms. Lethal concentrations of PCP for various species of fish range between 0.05 and 1 mg/L. Chronic effects often occur at 1/10th to 1/20th of the 96 hour LC50 concentration (Garrett and Shrimpton 1988). A monitoring study conducted during 1979 in British Columbia indicated that eight of nine wood protection facilities were discharging contaminated storm runoff with chlorophenate concentrations as high as 11 mg/L (Can Test Limited and EVS Consultants Limited 1979). Krahn and Shrimpton (1988) found that yard runoff from dip treated lumber at seven wood protection facilities in British Columbia ranged from 322 to 564 ug/L. Given the relatively high chlorophenol levels in surface soils at Atlantic Region wood protection facilities, the proximity of many of these operations to freshwater ecosystems and the fact that none of them have surface runoff collection/containment systems, adverse aquatic impacts resulting from the use of PCP at these operations would seem possible.

The threat to aquatic resources from boron contaminated soils at wood protection facilities in the region is more difficult to ascertain. Boron has been in widespread use for many years with no reports of undue impact on the environment (Agriculture Canada et al. 1989). Hamilton and Buhl (1990) observed that boron was relatively non-toxic (96-hr LC50s > 100 mg/L) to two life stages of Chinook and Coho salmon. Environment Canada reported that Ecobrite^{R} formulations, diluted to recommended concentrations and used at specified application rates, were far less toxic to salmonids than the chlorophenates (Agriculture Canada et al. 1989). However, in the same document, the Department of Fisheries and Oceans (DFO) reported that it was impossible to perform an assessment of the risk to fish, fish habitat and fisheries resources

from the proposed use of Ecobrite[R] for sapstain control. DFO indicated that the data base to support the registration of Ecobrite[R] was limited, particularly data on acute and chronic toxicity of borax to aquatic biota and the environmental fate of borax in the aquatic environment (Agriculture Canada et al. 1989).

Researchers in Finland have found a similar pattern of contamination at wood protection facilities using chlorophenates; soils have been heavily contaminated by chlorophenols and the chemicals have penetrated deeply, often into the groundwater (Kitunen et al. 1987; Kitunen et al. 1985; Valo et al. 1985; Valo et al. 1984). In addition, high concentrations of polychlorinated phenoxyphenols (PCPPs) and dibenzofurans (PCDFs) accumulated in surface soils (Kitunen et at. 1987; Kitunen et al. 1985; Valo et al. 1985; Humppi et al. 1984). Kitunen et al. (1987) found chlorophenols at concentrations up to 790 ug/g in soils at a depth of 105 cm, PCPPs up to 36 ug/g and PCDFs up to 3780 ug/kg in surface soils (0-5 cm depth). Valo et al. (1985) reported chlorophenol concentrations of 0.2 mg/L in groundwater (200 cm depth). Most Finnish researchers indicated that neither evaporation, biodegradation or photolytic degradation were able to mitigate the continued contamination of soil at these wood protection facilities, allowing chlorophenols to persist in the environment and potentially contaminate the groundwater at these sites.

Studies on the migration of boron in soils at wood protection facilities have not been conducted. Although the solubility of borax would indicate that some movement could be anticipated, Agriculture Canada et al. (1989) noted that if boron contaminated water percolates through soil, the boron concentration is likely to be reduced or eliminated depending on soil type and other factors.

The use of chlorophenates in wood protection has declined substantially in Canada (Agriculture Canada et al. 1989). In British Columbia in 1989, 59 of 70 anti-sapstain operations had already switched from chlorophenates to alternative anti-sapstain chemicals (B.C. Ministry of Environment 1989). The B.C. Antisapstain Chemical Waste Control Regulation under the Waste Management Act strictly controls the use of

chlorophenols and other anti-sapstain chemicals used in wood protection (Province of British Columbia, 1989). In June of 1987, Agriculture Canada released a discussion document on PCP that summarized the science base and other technical information known at that time (Agriculture Canada 1987). Based on response to that document and multi-stakeholder consultations, the registration of all sapstain control uses of pentachlorophenol in Canada terminated on December 31, 1990 (Agriculture Canada 1990).

Prior to 1990, the dramatic decline in use of PCP in British Columbia wood protection operations had not been experienced to the same degree in the Atlantic Region. Six of the eleven wood protection facilities in the region were still using chlorophenates in 1989. Five of the six sawmills using PCP in the region were treating white pine or hardwoods for the domestic market. This was something of an anomaly since the use of anti-sapstain chemicals has been traditionally associated with lumber for the export market.

Alternatives to PCP do exist, although they may not control the full spectrum of fungal organisms. Three alternatives currently registered include 2-(thiocyanomethylthio)benzothiazole (TCMTB), Copper-8-quinolinolate (Copper-8) and borax. Alternatives with temporary registration include didecyldimethyl ammonium chloride (DDAC), 3-iodo-2-propynyl butyl carbamate (IPBC) and azaconazole (Agriculture Canada 1990[a]; Agriculture Canada 1990[b]). Although registered and used in a number of other countries, none of these alternatives have the comprehensive database normally required for registration in Canada under the Pest Control Products Act. The alternatives have been registered in Canada with less than an ideal science database to achieve the early phase out of antisapstain use of chlorophenates and to provide the lumber industry access to a range of products necessary to protect lumber export markets. Concerns regarding the high acute and/or chronic toxicity of TCMTB, Copper-8, DDAC, IPBC and azaconazole to aquatic biota have been identified by Environment Canada and the Department of Fisheries and Oceans (Agriculture Canada et al. 1989).

Chlorophenol contamination of soils at wood protection facilities in this region will likely decline as inventories of PCP purchased before

the Dec. 31, 1990 termination date for purchase are used up. Without the continued input of chlorophenol contaminants to the soil, degradation of chlorophenols, primarily by microbial activity, would be expected (Garrett and Shrimpton 1988).

Results of this study strongly indicate that the magnitude and extent of soil contamination at wood protection facilities in the region reflects the level of environmental protection measures employed at the sawmills. In almost all instances the dip tanks were located on unprotected bare soil, the dip tanks were uncovered and subject to overflow during periods of heavy precipitation, and there were no runoff collection/containment systems in the storage areas. Inadequate drying time after the lumber was dipped was a problem at a number of operations as lumber was observed dripping on bare soil in the storage area. In addition, most facilities did not protect freshly treated lumber from precipitation (e.g. roofed initial storage area). The implementation of recommended design features outlined in the 'Code of Good Practice' for Chlorophenate Wood Protection (Konasewich et al. 1983) would protect the environment from harmful exposure to anti-sapstain chemicals at Atlantic Region wood protection facilities.

5.0 Recommendations

1. Owners and operators of wood protection facilities in the region should immediately improve operational practices used at their sawmills to prevent further contamination of soils. Improvements should be made, where necessary, in providing secure containment of anti-sapstain solutions in treatment areas, containing and collecting spills and drips in treatment areas and minimizing carry-over and spillage of anti-sapstain solutions throughout their facilities.

2. Given the high concentrations of contaminants in surface soils at wood protection facilities in the Atlantic Region, the following additional studies should be conducted by the appropriate government agencies.

- The concentration of contaminants in surface runoff and impacts on nearby aquatic ecosystems should be determined. This is particularly important since PCP and alternative antisapstain chemicals containing TCMTB, Copper-8, IPBC and DDAC, are highly toxic to aquatic organisms (Agriculture Canada et al. 1989) and little data is available on the chronic impacts of alternative anti-sapstain chemicals on aquatic ecosystems;
- Studies should be undertaken to determine the extent of contamination at various soil depths and whether there has been groundwater contamination at sites using PCP. Sites where PCP has been used for an extended period of time and/or use groundwater for drinking water supplies should be the priority study sites. Data from that study would provide information for site remediation if required;
- The concentrations of polychlorinated phenoxyphenols and dibenzofurans in surface soils at sites using chlorophenates should be determined. Data from that study would also provide information for site remediation if required.

3. Given the nature of wood protection operations, their potential for environmental damage and the large volumes of anti-sapstain chemicals used, provincial environment departments should consider licensing or permitting these operations under their relevant pesticide control or environmental protection legislation. To be eligible for licenses or permits to conduct wood protection operations, the following minimum standards should be met:
   - drip pads for spill and drip containment around the dip tanks should be installed;
   - adequate time (at least 30 minutes) should be allowed for treated wood to drip before it is transported to storage areas;
   - treated wood should be stored in an area which is roofed, paved and curbed for a minimum period of two hours following the initial drip period;
   - dip tanks should be covered when not in use;
   - an environmental monitoring program (e.g. surface runoff, groundwater) should be developed in consultation with the appropriate government agency.

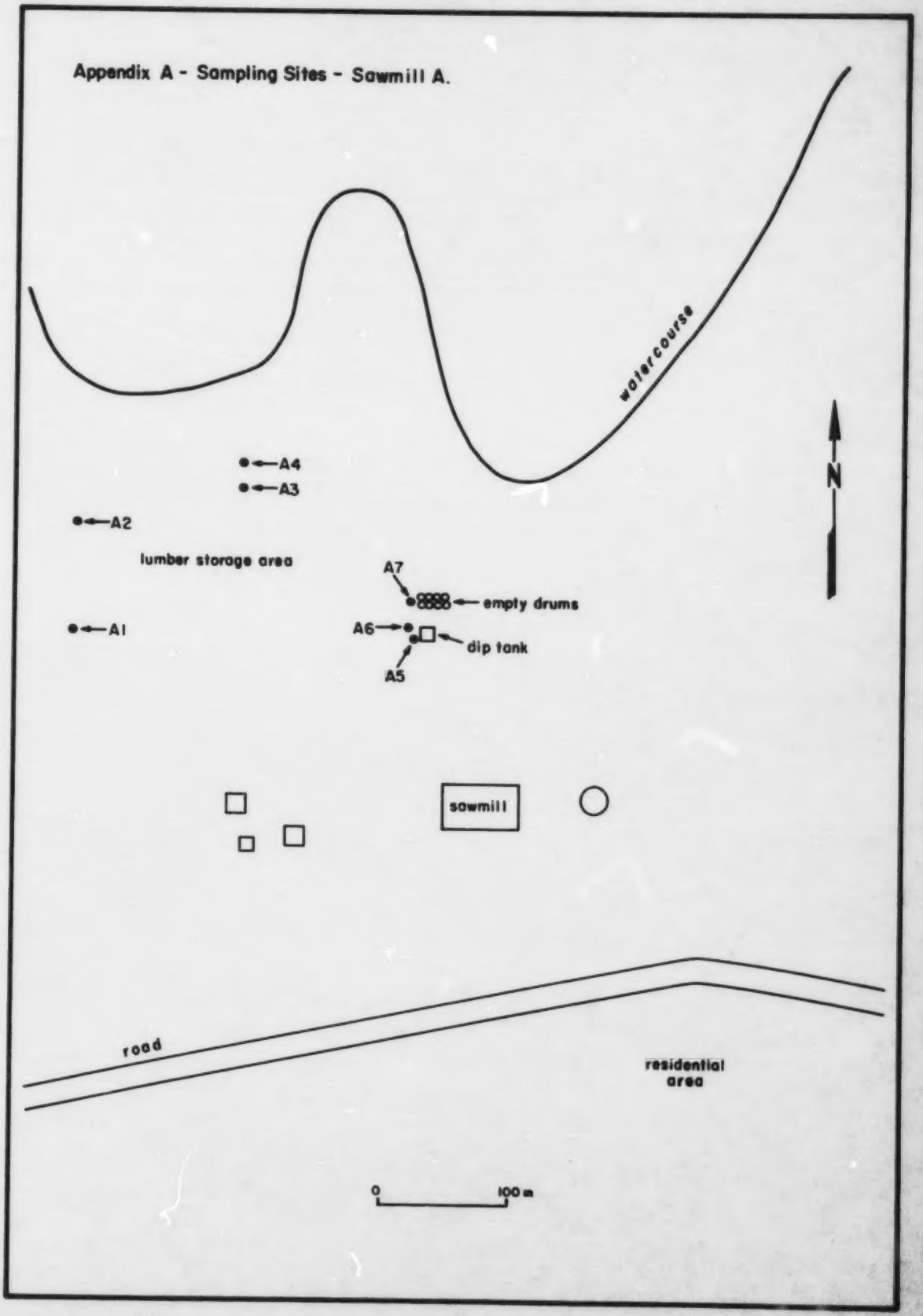
4. Agriculture Canada should consider adding more use restrictions on anti-sapstain chemicals, particularly restrictions aimed at providing secure containment of anti-sapstain solutions in the application area of a facility, minimizing carry-over and spillage of anti-sapstain solutions from the treatment areas, and containing and collecting spills and drips from the treatment area. Enforcement of use restrictions identified on product labels should be increased.

5. A regional "Code of Good Practice" for wood protection operations that is applicable to the use of all anti-sapstain chemicals should be developed.

6. Given the fact that CCME interim assessment criteria for chlorophenols (0.05 ug/g dry weight) and boron (1.0 ug/g dry weight-hot water soluble) are exceeded at all wood protection facilities in the region using PCP and Ecobrite^{R}, owners and operators of these facilities should consider investigative action to assess the extent of contamination, the nature of any hazards at a site, and to determine the scale and urgency of further action, if required. Remedial action at sites where CCME interim remediation criteria for chlorophenols are exceeded (5.0 ug/g dry weight) should be initiated.

7. Given the fact that the objective of wood protection has been traditionally focused on the protection of lumber exports during transit in conditions conducive for sapstain growth, sawmill operators in the region treating lumber for the domestic market should be encouraged to refrain from this practice, if possible. Scheduling the processing of this lumber during late autumn and early winter when below freezing temperatures substantially reduce sapstaining and other fungal problems in lumber would be helpful. Alternatively, kiln drying should be encouraged as an effective method to remove the water source essential for fungal growth on lumber.

Appendices

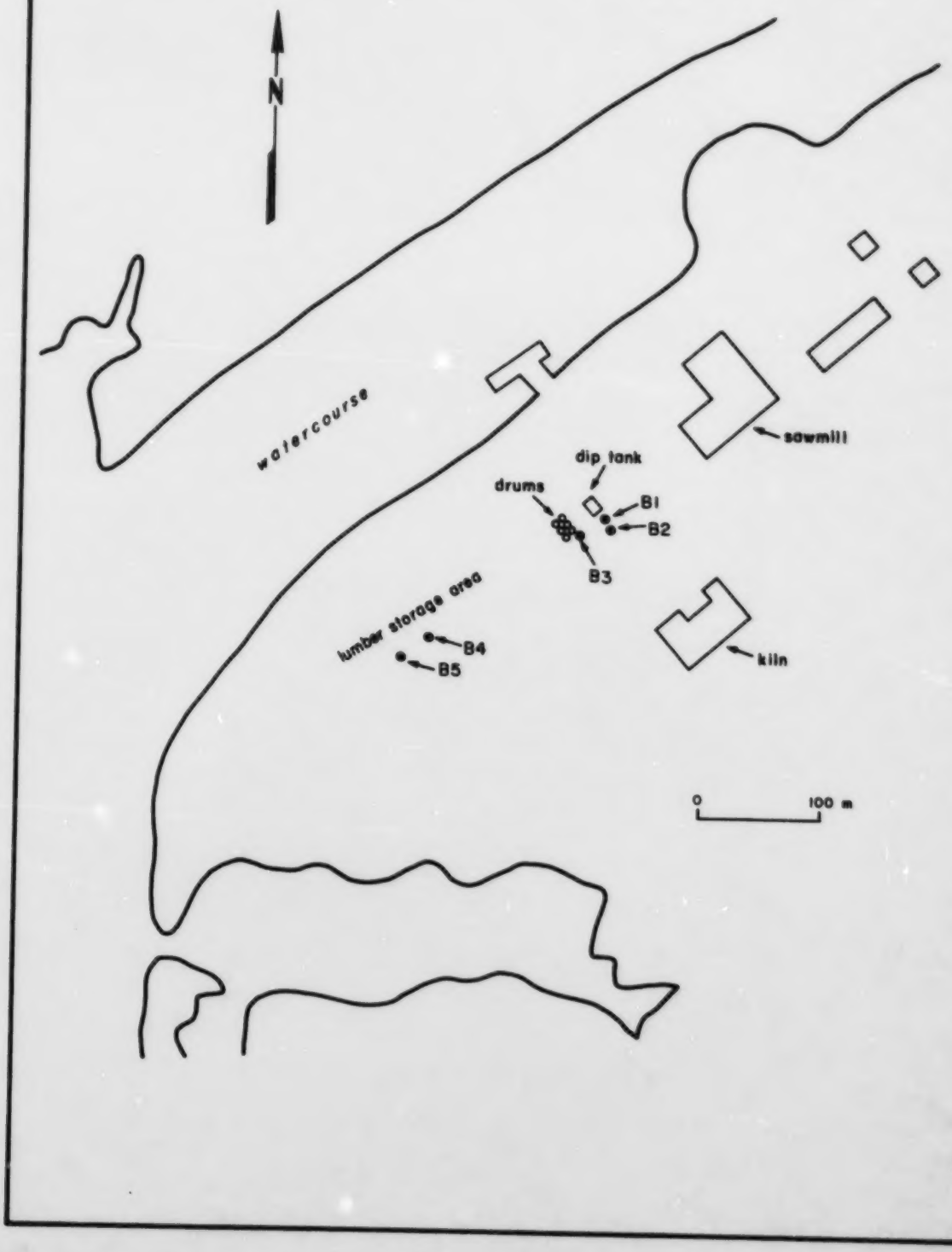

Appendix A - Sampling Sites - Sawmill A.
watercourse
N
A4
A3
A2
lumber storage area
A7
empty drums
A6
dip tank
A5
A1
sawmill
road
residential area
0
100 m

Sawmill A - Analytical Results (ug/g) dry weight

- sampling date - Aug. 21, 1989
- product used - Ecobrite C, P.C.P. # 20776

Sample No.	Sample Description	Sample Location	Boron
A1	sand/gravel	-west edge of lumber storage area; adjacent bundle of spruce treated June 1989	95
A2	wet sand/gravel	-northwest corner of lumber storage area; adjacent bundle of spruce treated June 1989.	44
A3	sand/gravel	-north end of lumber storage area; adjacent bundle of spruce treated August 1989.	79
A4	mucky sand/gravel	-north edge of lumber storage area, in puddle under bundle of spruce treated August 1989.	100
A5	wet sand/gravel/wood chips	-foot of dip tank	378
A6	sand/gravel	-5 m from dip tank	263
A7	sand/gravel	-adjacent empty Ecobrite drums, 5 m from dip tank	29

Appendix B – Sampling Sites – Sawmill B.

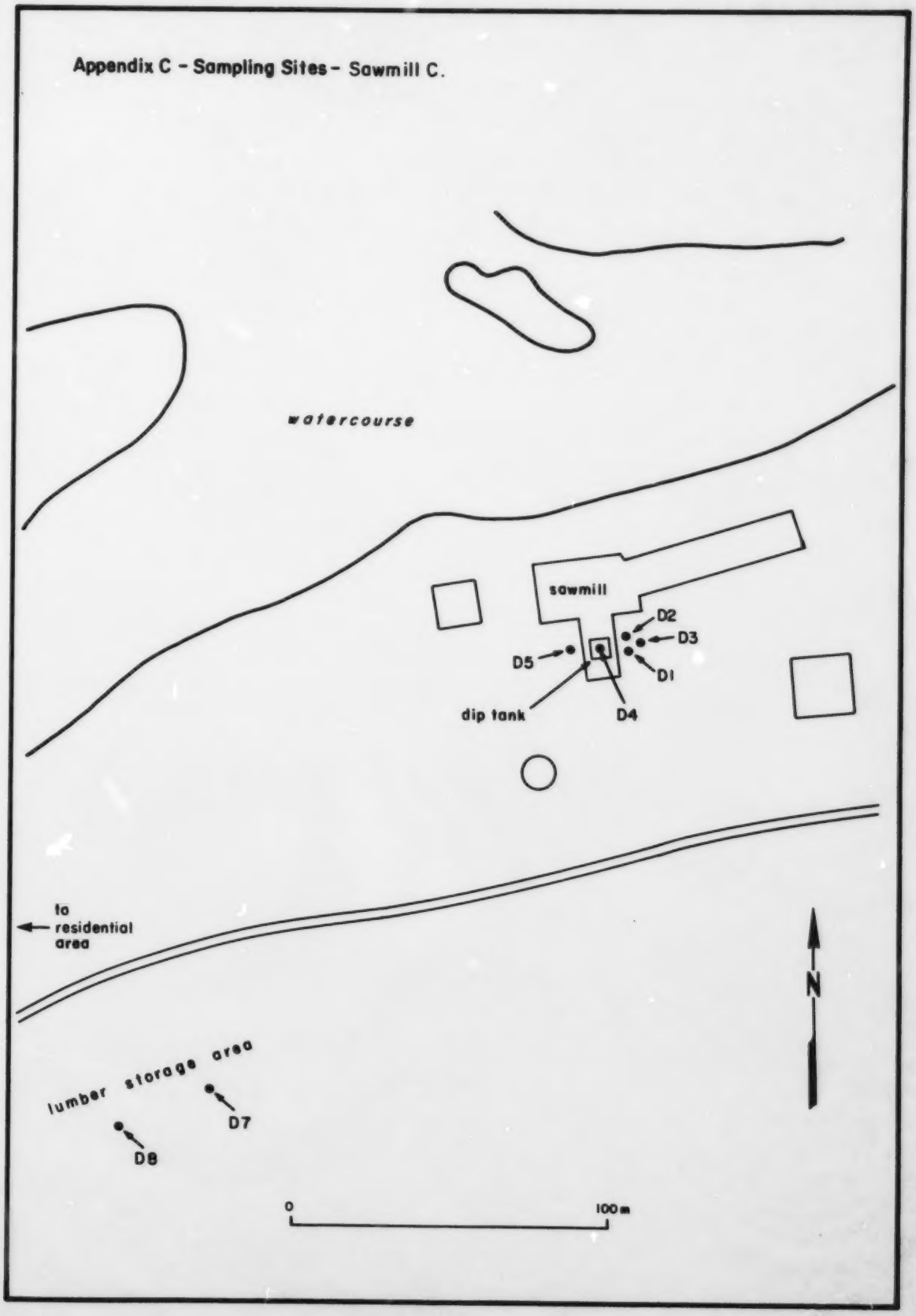


Sawmill B - Analytical Results (ug/g) dry weight

- sampling date - Aug. 21, 1989
- product used - Ecobrite C, P.C.P. # 20776

Sample No.	Sample Description	Sample Location	Boron
B1	mucky sand/gravel/ wood chips	-foot of dip tank	62
B2	mucky sand/gravel	-5 m from dip tank	30
B3	sand/gravel	-adjacent full drums of Ecobrite, 5 m from dip tank	33
B4	sand/gravel	-adjacent bundle of spruce treated August 15, 1989	34
B5	sand/gravel	-adjacent bundle of spruce treated July 1989	25

Appendix C - Sampling Sites - Sawmill C.



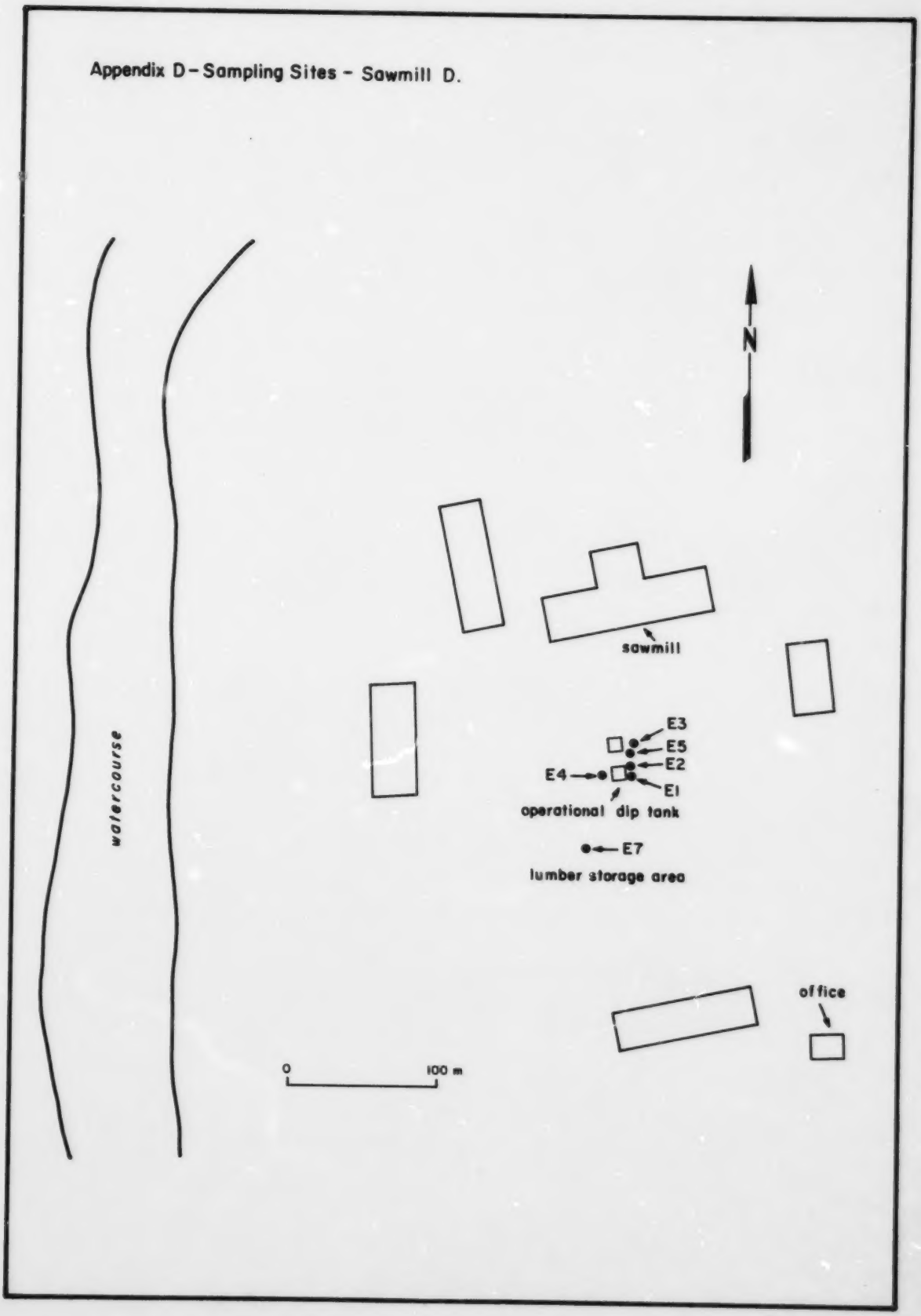
Sawmill C - Analytical Results (ug/g) dry weight

- sampling date - Aug. 22, 1989
- product used - Permatox 10-S, P.C.P. # 8146
- this sawmill ceased wood protection activities in 1990

Sample Description	Sample Location	PCP	2,3,5,6-TTCP	2,3,4,5-TTCP	2,4,6-TCP	TTCC	2,4,5-TCP	2,5-DCP	2,3,4-TCP	2,3,5-TCP	2,3,6-TCP	Boron
Sample No. D1 wood chips/sand	-3 m from dip tank, east side	370	0.34	0.39	<0.005	0.015	<0.005	<0.1	<0.005	<0.005	<0.005	67
Sample No. D2 wood chips/sand	-3 m from dip tank, east side	250	1.0	0.093	<0.005	0.0087	<0.005	<0.1	<0.005	<0.005	<0.005	83
Sample No. D3 sand/gravel	-5 m from dip tank, east side	0.32	0.022	0.011	<0.005	0.0033	<0.005	<0.1	<0.005	<0.005	<0.005	22
Sample No. D4 wood chips/sand	-under dip tank	930	1.9	0.032	0.0059	0.0009	<0.005	<0.1	<0.005	<0.005	<0.005	522
Sample No. D5 wood chips/ sand/loam	-3 m from dip tank, west side	0.029	0.023	0.015	<0.05	0.0032	<0.005	<0.1	<0.005	<0.005	<0.005	24
Sample No. D7 sand/gravel	-adjacent bundle of pine treated April 27, 1989	0.034	tr	0.0022	tr	0.0002	<0.005	<0.1	<0.005	tr	<0.005	19
Sample No. D8 sand/gravel	-adjacent bundle of pine treated May 11, 1989	0.061	0.0026	0.0048	tr	0.00094	tr	<0.1	<0.005	tr	<0.005	19

tr = trace
PCP = pentachlorophenol, TTCP = tetrachlorophenol, TCP = trichlorophenol, TTCC = tetrachlorcatechol, DCP = dichlorophenol

Appendix D – Sampling Sites – Sawmill D.

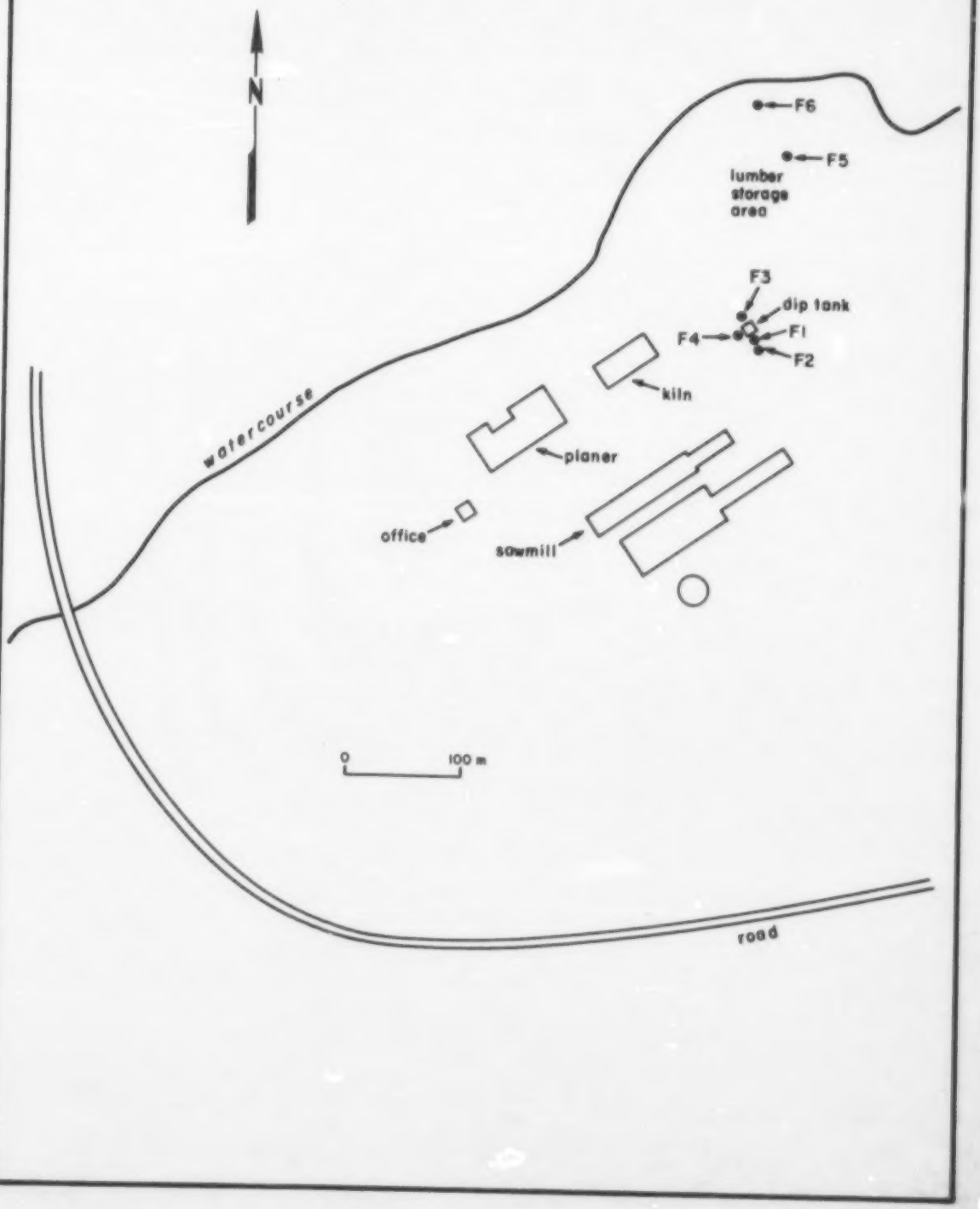


Sawmill D - Analytical Results (ug/g) dry weight

- sampling date - Aug. 23, 1989
- product used - Ecobrite C, P.C.P. # 20776

Sample No.	Sample Description	Sample Location	Boron
E1	mucky sand/gravel	-foot of dip tank, adjacent puddle	355
E2	mucky sand/gravel	-corner of dip tank, adjacent puddle	229
E3	mucky sand/gravel	-8 m from dip tank, bottom of brownish oily puddle	847
E4	sand/gravel	-foot of dip tank, non-working side	68
E7	sand/gravel	-adjacent bundle of spruce treated May 1989	24

Appendix E – Sampling Sites – Sawmill E.

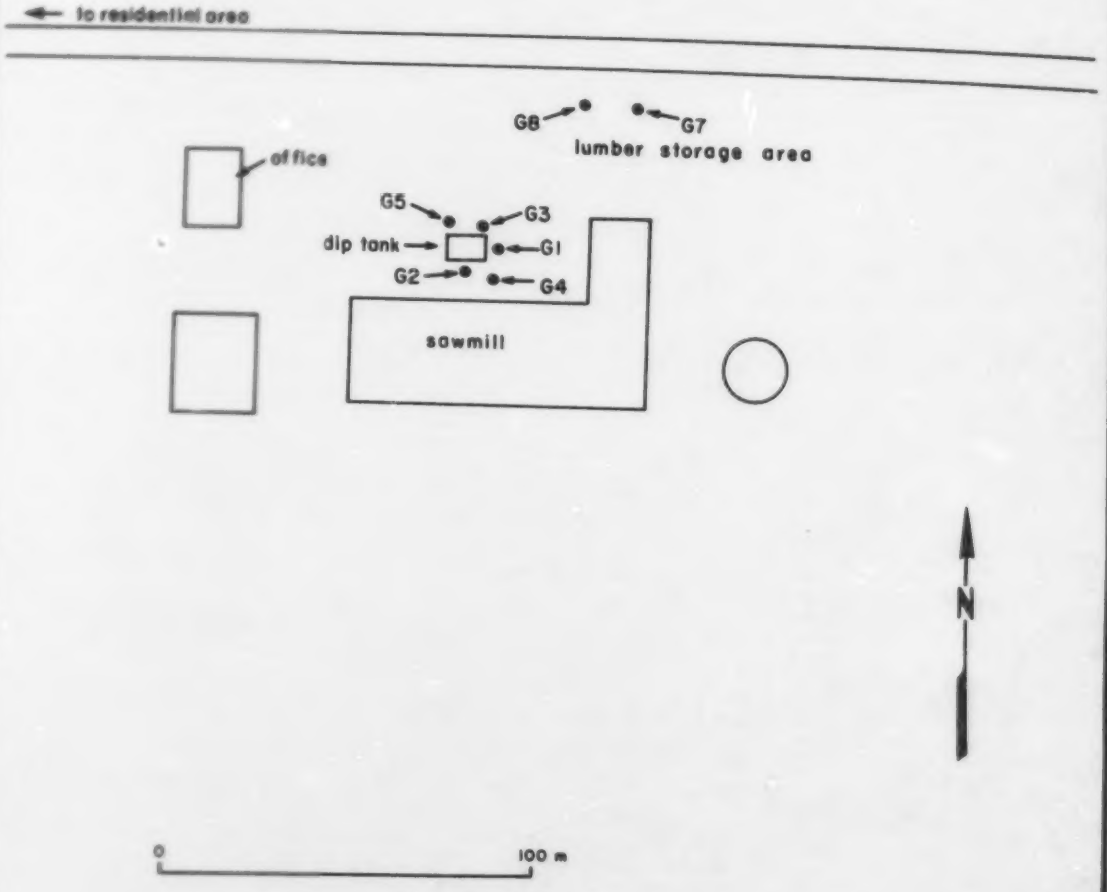


Sawmill E - Analytical Results (ug/g) dry weight

- sampling date - Aug. 23, 1989
- product used - Ecobrite C, P.C.P. # 20776

Sample No.	Sample Description	Sample Location	Boron
F1	sand/gravel/wood chips	-foot of dip tank	80
F2	sand/gravel/wood chips	-3 m from dip tank in depression	86
F3	sand/gravel/wood chips	-under drying table	77
F4	sand/gravel	-3 m from west end of dip tank	21
F5	sand/gravel	-adjacent bundle of spruce treated in Aug. 1989	22
F6	sand/gravel	-north edge of lumber storage area	22

Appendix F - Sampling Sites - Sawmill F



Sawmill F - Analytical Results (ug/g) dry weight

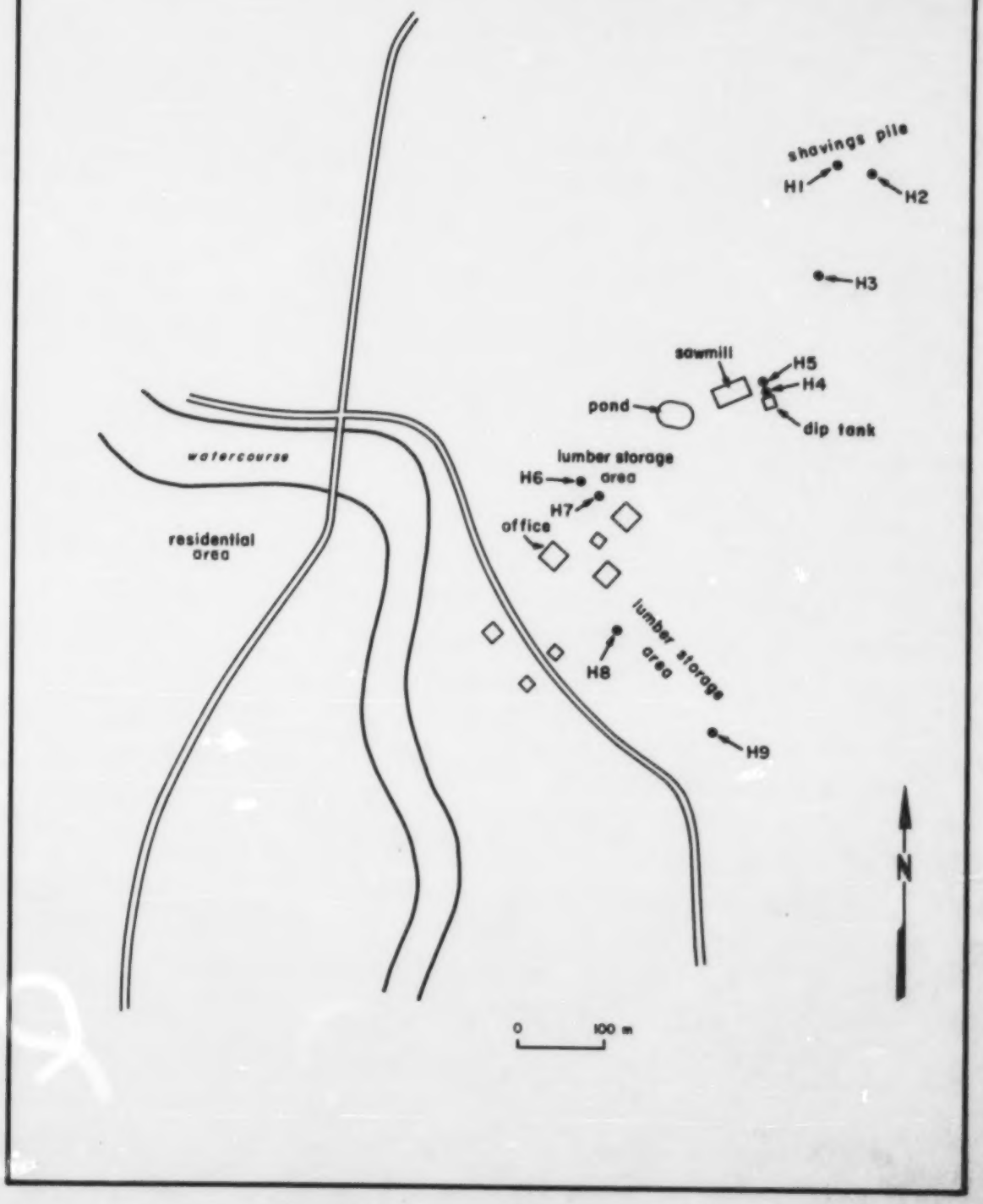
- sampling date - Aug. 23, 1989
- product used - Permatox 10-S, P.C.P. # 8146

Sample Description	Sample Location	PCP	2,3,5,6-TTCP	2,3,4,5-TTCP	2,4,6-TCP	TTCC	2,4,5-TCP	2,5-DCP	2,3,4-TCP	2,3,5-TCP	2,3,6-TCP	Boron
Sample No. G1 gravel/wood chips	-at side of dip tank near drainage valve	480	890	0.032	0.063	0.0025	0.041	<0.1	<0.005	<0.005	0.0085	156
Sample No. G2 gravel/wood chips	-foot of dip tank, non-working side	25	15	0.74	0.0051	0.017	4.7	<0.1	0.063	0.0084	tr	33
Sample No. G3 gravel/wood chips	-3 m from dip tank	97	190	0.38	0.15	0.016	1.4	<0.1	0.35	<0.005	0.031	52
Sample No. G4 wet gravel/ wood chips	-2 m from dip tank, non-working side	0.32	0.10	0.037	<0.005	0.022	0.045	<0.1	0.040	<0.005	<0.005	25
Sample No. G5 sawdust/gravel	-4 m from dip tank	240	330	4.5	0.079	0.070	24	<0.1	1.6	<0.005	0.025	34
Sample No. G7 wet loam/ gravel	-adjacent bundle of lumber that was still dripping	180	160	0.10	0.086	0.023	0.24	<0.1	0.12	<0.005	0.0075	50
Sample No. G8 loam/gravel	-adjacent bundle of lumber treated Aug. 1989	0.29	0.23	0.0032	<0.005	0.0005	<0.005	<0.1	<0.005	<0.005	<0.005	27

tr = trace

PCP = pentachlorophenol, TTCP = tetrachlorophenol, TCP = trichlorophenol, TTCC = tetrachlorcatechol, DCP = dichlorophenol

Appendix G - Sampling Sites - Sawmill G.



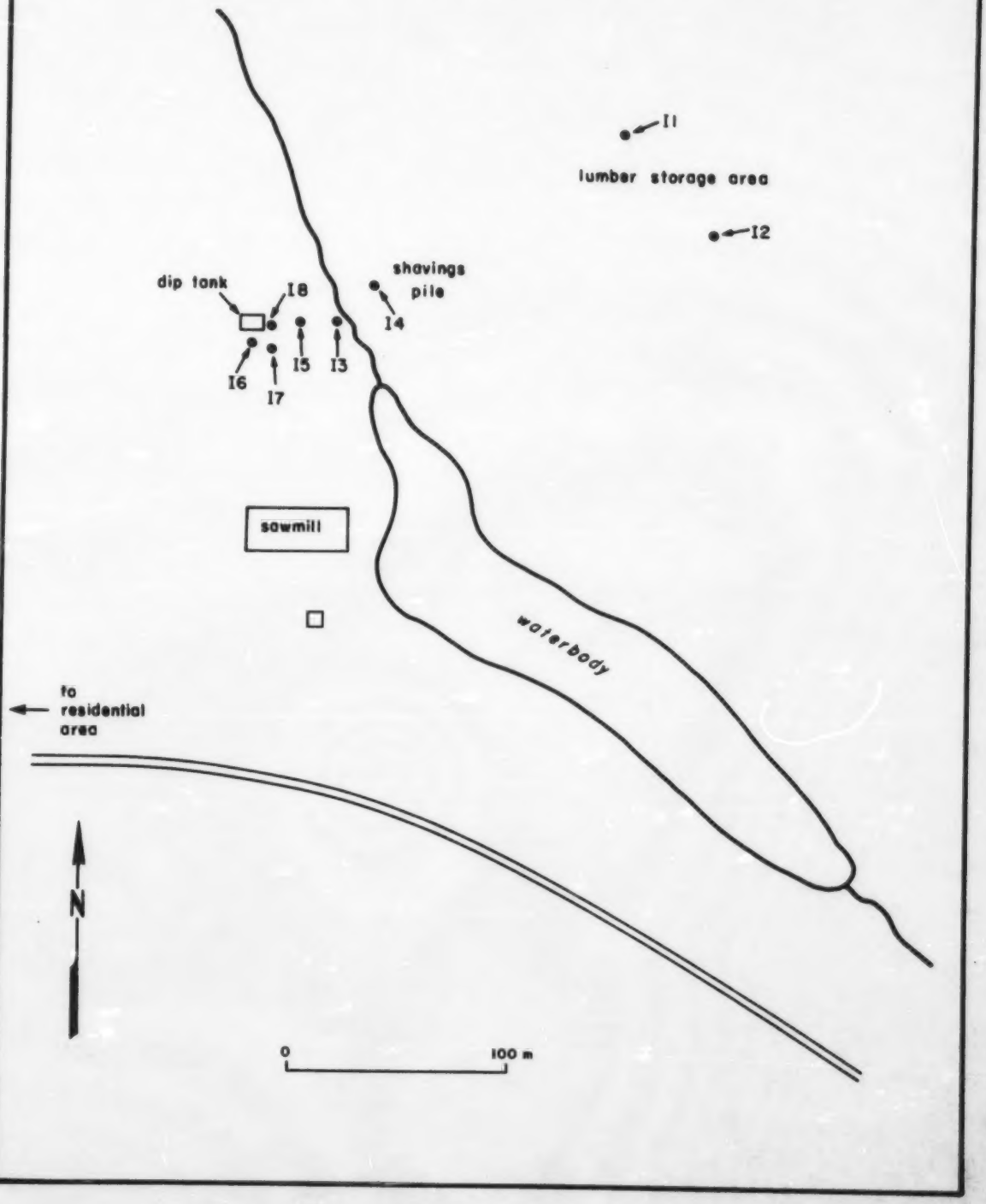
Sawmill G - Analytical Results (ug/g) dry weight

- sampling date - Aug. 30, 1989
- product used - Permatox 10 - S, P.C.P. # 8146

Sample Description	Sample Location	PCP	2,3,5,6-TTCP	2,3,4,5-TTCP	2,4,6-TCP	TTCC	2,4,5-TCP	2,5-DCP	2,3,4-TCP	2,3,5-TCP	2,3,6-TCP	Boron
Sample No. H1 wood shavings/ sawdust/loam	-adjacent shavings/ sawdust pile	0.59	0.014	0.042	<0.005	0.0035	<0.005	<0.1	<0.005	<0.005	<0.005	22
Sample No. H2 wood shavings/ sawdust/ loam	-adjacent shavings/ sawdust pile	0.093	0.0026	0.015	<0.005	0.00054	<0.005	<0.1	<0.005	<0.005	<0.005	29
Sample No. H3 loam/sawdust/ wood shavings	-in ditch approx. 125 m from dip tank, between dip tank and shavings pile	0.20	0.0035	0.018	<0.005	0.00065	<0.005	<0.1	<0.005	<0.005	<0.005	24
Sample No. H4 loam/gravel/ wood chips	-foot of dip tank	58	0.92	0.25	0.037	14	0.044	<0.1	0.30	<0.005	tr	369
Sample No. H5 loam/gravel/ wood chips	-5 m from dip tank in depression	900	5.1	0.20	0.0052	0.27	<0.005	<0.1	tr	<0.005	<0.005	617
Sample No. H6 loam/gravel	-lower edge of lumber storage area south of pond; adjacent bundle of treated pine	0.22	0.014	0.0083	<0.005	0.0014	<0.005	<0.1	<0.00	<0.005	<0.005	21
Sample No. H7 loam/gravel	-south east corner of lumber storage area south of pond; adjacent bundle of treated pine	0.12	0.0032	0.0039	<0.005	0.0032	<0.005	<0.1	<0.00	tr	<0.005	20
Sample No. H8 sand/gravel	-south west corner of lumber storage area southeast of office; adjacent bundle of treated pine	0.13	tr	0.0032	<0.005	0.00077	<0.005	<0.1	<0.00	<0.005	<0.005	20
Sample No. H9 sand/gravel	-south east corner of lumber storage area southeast of office; adjacent bundle of treated pine	0.013	<0.002	<0.002	<0.005	tr	<0.005	<0.1	<0.005	<0.005	<0.005	19

tr = trace
PCP = pentachlorophenol, TTCP = tetracholorphenol, TCP = trichlorophenol, TTCC = tetrachlorcatechol, DCP = dichlorophenol

Appendix H - Sampling Sites - Sawmill H



Sawmill H - Analytical Results (ug/g) dry weight

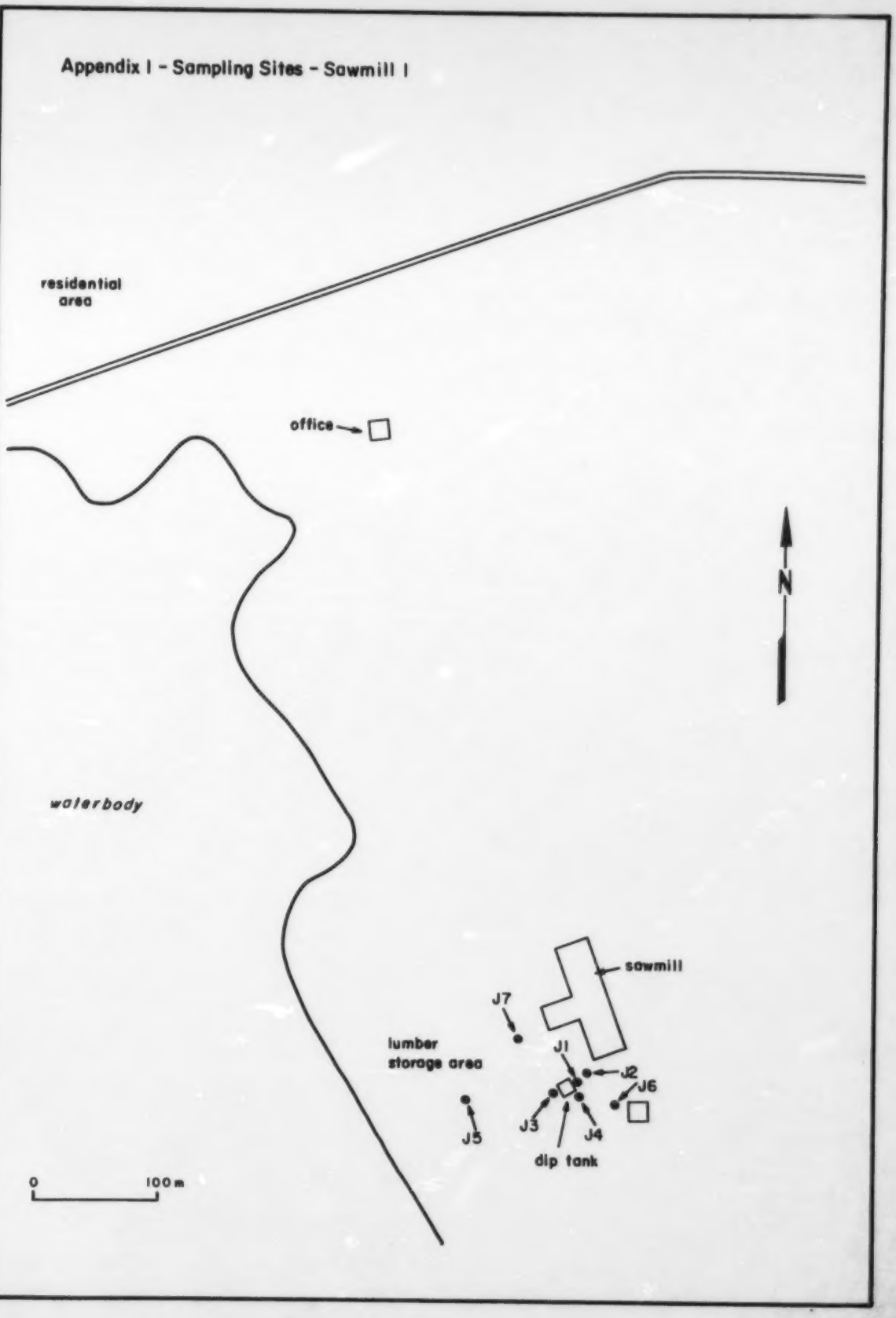
- sampling date - Aug. 30, 1989
- product used - Permatox 181, P.C.P. # 18919

Sample Description	Sample Location	PCP	2,3,5,6-TTCP	2,3,4,5-TTCP	2,4,6-TCP	TTCC	2,4,5-TCP	2,5-DCP	2,3,4-TCP	2,3,5-TCP	2,3,6-TCP	Boron
Sample No. I1 sand/loam	-north edge of lumber storage area; adjacent bundle of pine treated in 1988	0.071	tr	0.0076	<0.005	0.0024	<0.005	<0.1	<0.005	<0.005	<0.005	24
Sample No. I2 sand/loam	-southeast corner of lumber storage area; adjacent bundle of pine treated in 1987	0.020	tr	tr	<0.005	0.0011	<0.005	<0.1	<0.005	<0.005	<0.005	23
Sample No. I3 gravelly sediment	-in small stream approx. 50 m from dip tank, between dip tank and shavings pile	0.0025	<0.002	0.0026	<0.005	0.0002	<0.005	<0.1	<0.005	<0.005	<0.005	12
Sample No. I4 sawdust/wood shavings/loam	-foot of sawdust/ shavings pile	0.77	0.012	0.031	<0.005	0.010	<0.005	<0.1	<0.005	<0.005	<0.005	19
Sample No. I5 sand/gravel	-25 m from dip tank at bottom of bank	0.063	<0.002	<0.002	<0.005	<0.0002	<0.005	<0.1	<0.005	<0.005	<0.005	22
Sample No. I6 sand/gravel	-foot of dip tank	71	0.96	1.2	tr	1.8	0.028	<0.1	0.061	0.037	<0.005	21
Sample No. I7 sand/gravel	-7 m from dip tank	0.82	0.016	0.060	<0.005	0.049	0.015	<0.1	0.0017	<0.005	<0.005	25
Sample No. I8 sand/gravel	-below drainage valve on dip tank	87	0.48	0.6	0.0066	17	0.014	<0.1	0.43	<0.005	<0.005	30

tr = trace

PCP = pentachlorophenol, TTCP = tetrachlorophenol, TCP = trichlorophenol, TTCC = tetrachlorcatechol, DCP = dichlorophenol

Appendix I - Sampling Sites - Sawmill I



Sawmill I - Analytical Results (ug/g) dry weight

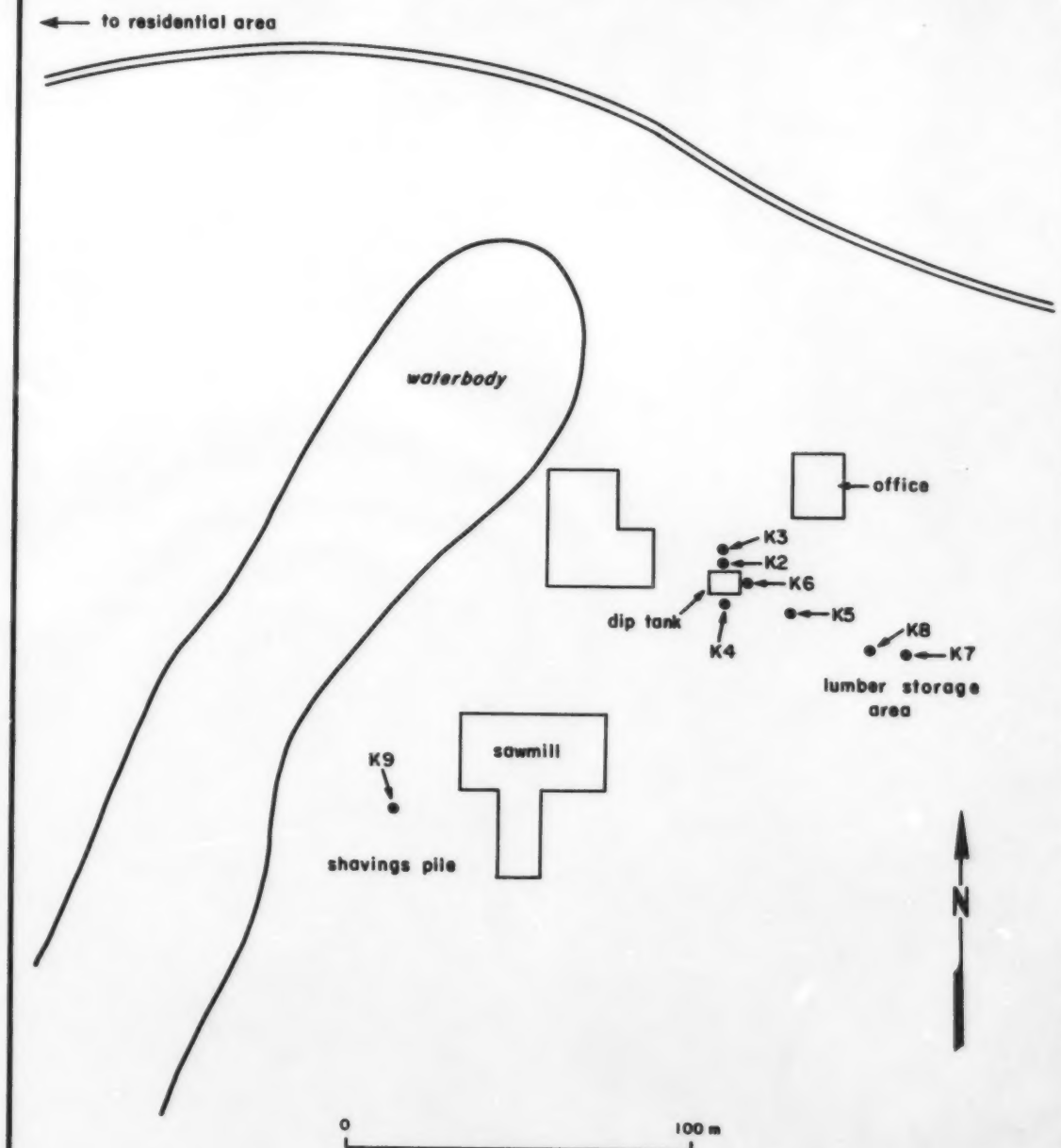
- sampling date - Aug. 30, 1989
- product used - Permatox 10 - S, P.C.P. # 8146

Sample Description	Sample Location	PCP	2,3,5,6-TTCP	2,3,4,5-TTCP	2,4,6-TCP	TTCC	2,4,5-TCP	2,5-DCP	2,3,4-TCP	2,3,5-TCP	2,3,6-TCP	Boron
Sample No. J1 sand/gravel	-foot of dip tank	5.2	0.11	0.038	<0.005	0.17	<0.005	<0.1	tr	<0.005	<0.005	21
Sample No. J2 sand/gravel	-5 m from dip tank	8.1	0.30	0.062	0.0077	0.11	0.011	<0.1	0.0059	<0.005	<0.005	19
Sample No. J3 sand/gravel	-2 m from dip tank, non-working side	150	1.1	0.27	0.0072	0.40	0.013	<0.1	tr	<0.005	<0.005	22
Sample No. J4 wood chips/sand /gravel	-in depression next to end of dip tank	4.6	0.072	0.028	<0.005	0.054	<0.005	<0.1	<0.005	<0.005	<0.005	23
Sample No. J5 sand/gravel	-adjacent bundle of treated pine	3.1	0.030	0.018	<0.005	0.048	<0.005	<0.1	<0.005	<0.005	<0.005	18
Sample No. J6 sand/gravel	-in drainage ditch at bottom of road to lumber storage area	0.089	tr	0.0025	<0.005	0.00084	<0.005	<0.1	<0.005	<0.005	<0.005	28
Sample No. J7 sand/gravel	-in drainage ditch 40 m north of dip tank	0.56	0.0077	0.0083	<0.005	0.040	<0.005	<0.1	<0.005	<0.005	<0.005	28

tr = trace

PCP = pentachlorophenol, TTCP = tetrachlorophenol, TCP = trichlorophenol, TTCC = tetrachlorcatechol, DCP = dichlorophenol

Appendix J - Sampling Sites - Sawmill J



Sawmill J - Analytical Results (ug/g) dry weight

- sampling date - Aug. 31, 1989

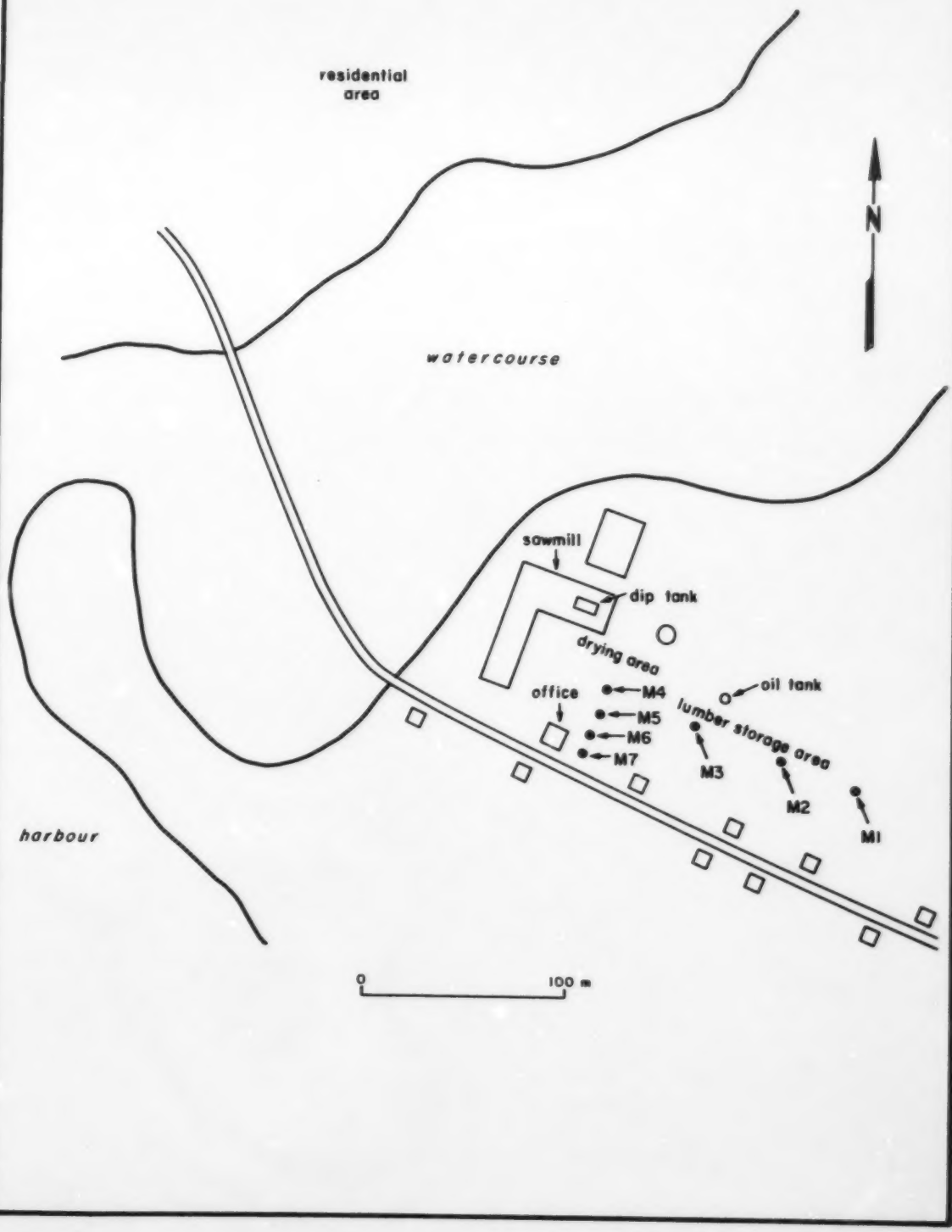
- product used - Permatox 10 - S, P.C.P. # 8146

Sample Description	Sample Location	PCP	2,3,5,6-TTCP	2,3,4,5-TTCP	2,4,6-TCP	TTCC	2,4,5-TCP	2,5-DCP	2,3,4-TCP	2,3,5-TCP	2,3,6-TCP	Boron
Sample No. K2 wood chips/ sawdust/gravel	-foot of dip tank next to puddle	340	10	0.92	0.012	0.99	0.092	<0.1	0.12	<0.005	0.0027	110
Sample No. K3 gravel/wood chips (wet)	-7 m from dip tank	710	18	2.7	0.029	53	0.17	<0.1	0.83	<0.005	0.0068	157
Sample No. K4 sand/gravel/ wood chips	-foot of dip tank, non-working side	240	11	0.49	0.012	2.0	0.041	<0.1	0.12	<0.005	<0.005	58
Sample No. K5 mucky sand/ gravel	-20 m from dip tank	41	1.4	0.19	tr	0.52	tr	<0.1	0.052	tr	tr	44
Sample No. K6 gravel/wood chips/sawdust	-in depression at end of dip tank	1300	25	0.48	0.0098	1.1	0.021	<0.1	0.049	<0.005	<0.005	158
Sample No. K7 sand/loam/ wood chips	-adjacent bundle of spruce treated August 1989	1000	2.6	0.27	0.0079	0.076	0.027	<0.1	<0.005	<0.005	<0.005	29
Sample No. K8 sand/loam/ wood chips	-adjacent bundle of spruce treated Aug '89	1.6	0.087	0.029	<0.005	0.016	<0.005	<0.1	<0.005	<0.005	<0.005	29
Sample No. K9 wood shavings	-shavings pile	1.4	0.069	0.029	<0.005	0.016	<0.005	<0.1	<0.005	<0.005	<0.005	18

tr = trace

PCP = pentachlorophenol, TTCP = tetrachlorophenol, TCP = trichlorophenol, TTCC = tetrachlorcatechol, DCP = dichlorophenol

Appendix K - Sampling Sites - Sawmill K.



Sawmill K - Analytical Results (ug/g) dry weight

- sampling date - Sept. 7, 1989

- product used - Ecobrite C, P.C.P. # 20776

Sample No.	Sample Description	Sample Location	Boron
M1	sand/gravel	-east end of lumber storage area; adjacent bundle of spruce treated Sept. 1989	25
M2	wet sand/gravel	-adjacent puddle in lumber storage area	30
M3	wet sand/gravel	-adjacent puddle in lumber storage area; across from tank	29
M4	wood chips/sand	-10 m from drying area; in depression	273
M5	mucky wood chips/sand	-15 m from drying area; adjacent puddle	186
M6	mucky wood chips/sand	-30 m from drying area	117
M7	mucky wood chips/sand	-50 m from drying area at entrance to storm sewers	49

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